# SCIENCE:

*A WEEKLY NEWSPAPER OF ALL THE ARTS AND SCIENCES.*

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## ESTIMATES OF DISTANCE.

HERBERT NICHOLS, in his experiments on "The Psychology of time" (*American Journal of Psychology*, April, 1891), has shown that estimates of time intervals are influenced by immediately preceding estimates, so that, in general, intervals are judged to be longer after practice on estimating an actually longer interval than when no such practice precedes, and shorter after practice on a shorter interval. The experiments about to be described were undertaken to see whether the same rule applies to estimates of distance. They show no such effect, perhaps because the intervening practice was not sufficiently sustained to affect the judgment. But the results are interesting for several reasons, and they are therefore given below.

The mode of experimenting was as follows: On each of three sheets of unruled paper (about six by nine inches) was placed a pair of pencil dots; on the first these were 4.02 inches apart; on the second .92 of an inch; on the third exactly the same distance as on the first. Without being told the object of the experiments, the person to be experimented on was shown the first pair of dots, allowed to look at them as long as he pleased, and then, the paper being taken away, told to make from memory, on a slip $9 \times \frac{1}{2}$ inches, two dots at the same distance apart, as nearly as he could. This was repeated on a fresh sheet, without his looking at the model again, and so on till he had made ten trials. The same thing was then repeated with the second and third sheets.

The following table shows the results, the first column giving the difference between the actual distance of the dots and the average of the ten estimates in each series; the second column the percentage of this difference to the actual distance; the third the mean deviation of the estimates from the average (taken always as positive); and the fourth the percentage of this mean to the actual distance. All distances are in decimals of an inch.

| Persons. | Error of Average. | | | Per Cent. | | | Mean Deviation from Average. | | | Per Cent. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | I. | II. | III. | I. | II. | III. | I. | II. | III. |
| S. S.... | +.65 | −.17 | +.92 | 16 | 16 | 23 | .13 | .04 | .12 | 3 | 4.5 | 3 |
| J. S.... | −.10 | +.21 | +.70 | 2 5 | 23 | 17 | .14 | .13 | .14 | 3 | 14 | 3 |
| A. L. B. | −1.35 | −.30 | −1.31 | 33 5 | 33 | 32.5 | .14 | .07 | .25 | 4 | 5 | 6 |
| E. S.... | +.26 | +.31 | −.19 | 6 | 33 | 5 | .31 | .09 | .23 | 8 | 10 | 6 |
| L. B... | + 75 | +.18 | +.68 | 19 | 19.5 | 17 | .24 | .04 | .26 | 6 | 5 | 6 |
| M. S.... | −.31 | +.20 | +.45 | 8 | 21 | 11 | .17 | .09 | .28 | 4 | 9 | 7 |
| L. F.... | +.05 | +.07 | −.01 | 1 | 7.5 | 0.2 | .09 | .04 | .06 | 2 | 4 | 1.5 |

The degree to which the absolute value of the errors depends on previous training is plainly shown; for instance, L. F., in whose case they are remarkably small, is the daughter of a well-known artist and herself accomplished in the use of the pencil, while A. L. B. is a boy five years of age. The consistency of the estimates seems, however, to depend much less on training, as shown in the third column, the ratio of A. L. B's. mean deviations to those of L. F. being about 1.5, 1.7, and 6.8 for the three series respectively, while the ratios of their errors (from the first column) are 27, 4, and 131. In the cases of S. S., A. L. B., and L. B. the errors are nearly proportional to the actual length of the intervals, which would seem the natural rule; but in the other cases there seems a tendency toward making errors of the same absolute value in estimating both short and long intervals. A. L. B., whose absolute errors are far the largest, keeps them most nearly proportional. The mean deviations are much more generally proportional to the intervals, the most noticeable exception being that of J. S.—also the chief exception to proportionality in the former case.

ARTHUR E. BOSTWICK.

## THE LATEST ADVANCES IN SPECTRUM PHOTOGRAPHY.

A LETTER just received by the present writer from Mr. Victor Schumann of Leipzig, whose work in the domain of spectrography is less widely known and appreciated than it deserves to be, reveals such surprising advances within the past year in photographing radiations in the ultra-violet spectrum, that I am impelled to present the following summary of Mr. Schumann's results.

More than two years ago he demonstrated the remarkable absorptive effect of air upon very short vibrations, so great, indeed, that even the air within the tubes of the spectrograph was a serious obstacle to the investigation. However, he was able, with the apparatus then at hand, to demonstrate the existence of lines up to and beyond wave-length 1,852 by photography, using the light of the aluminum spark.

With the fine skill and ingenuity which has ever characterized his work, Mr. Schumann has since constructed a spectrograph exhausted of air, with lenses and prism of white fluor-spar. The source of light for these researches was the hydrogen Geissler tube. With the "exhausted spectroscope," as it is termed, and plates of proper sensitiveness, Mr. Schumann finds the photographic action of the spectrum beyond wave-length 1,852 very strong indeed. It is composed of fourteen groups of lines, including altogether about six hundred lines. The boundary of this hitherto en-

tirely unknown portion of the spectrum extends about four times as far from the most refrangible line hitherto photographed (the aluminum line 1,852), as that line is beyond the blue hydrogen line of wave-length 4,861. The interest in these researches is, therefore, very great; and it seems as though the limit of the radiations might only be reached when we can detect them in the universal ether itself, unaffected by a trace of an absorptive medium, and with photographic plates of special character.

The ordinary plates do not serve for work of this kind. The plates used by Mr. Schumann are specially made by himself, and are peculiar in possessing great sensitiveness to the ultra-violet rays, but relatively very little to the light of the visible spectrum. Because of this insensitiveness to the visible spectrum, the plate acts toward the ultra-violet precisely like one exposed to filtered light, from which all the rays have been absorbed, which, as diffused light in the spectrograph, would tend to cause fogginess of the picture. Such is the effect when an attempt is made to photograph the ultra-violet spectrum with an ordinary plate; for, before the ultra-violet rays have affected the plate, or produced a distinct image, the plate is fogged all over by the diffused light. The method of making the new plates is not yet published, because the investigations are not yet completed nor ready for publication.

Photography in a vacuum presents some difficulties and requires far greater care than under ordinary conditions, even under the most favorable conditions the photographic effect of these extremely refrangible radiations is relatively so very weak that on many plates prepared according to the new method it was difficult to establish even the existence of the vibrations of the shortest wave-lengths.

We may look forward with the greatest interest to the early publication of full details and results of this most skilfully conducted investigation, which has so greatly extended the known limits of the invisible spectrum.

ROMYN HITCHCOCK.

1455 Mass. Ave., Washington, D.C., Feb. 20.

## METALS AT HIGH TEMPERATURES.

ON Feb. 5, Professor Roberts-Austen, C.B., gave a very interesting lecture on metals at high temperatures at the Royal Institution. As was to be expected, nothing very novel was brought forward, but the lecturer certainly succeeded in demonstrating to a large audience results which have hitherto been only obtained in the laboratory. Every one who has ever heard Professor Roberts-Austen lecture, knows his fondness for experimenting with gold, which no doubt is mainly due to his position at the mint, though, apart from this, many would find a certain fascination in handling and experimenting with such a metal. Moreover, gold is a metal remarkable for other properties besides its monetary value. On previous occasions Professor Roberts-Austen has drawn attention to the fact that its properties are changed in a most remarkable manner by alloying it with small percentages of other metals, and on the present occasion he exhibited a new series of alloys of this metal with aluminium which are of equal interest to those previously known. One of these alloys in particular, containing 20 per cent of aluminium, is noteworthy, as it forms an exception to the usual rule that the melting point of an alloy is lower than that of either of its constituents. This alloy, on the other hand, has a fusing point above that of gold, the most infusible of its constituents. Curiously enough, the alloy with 10 per cent of aluminium follows the ordinary rule. These alloys, it should be added, have the most brilliant colors. The 20 per cent alloy is a brilliant ruby in tint, whilst those containing greater percentages of aluminium are purple in hue.

With the aid of the oxy-hydrogen blowpipe and M. Le Chatelier's pyrometer, the lecturer was able to show a large audience the peculiarities of the cooling curves of several metals, and also to measure the fusing points of some of the most refractory of them. Indeed, he succeeded in fusing iridium, using for the purpose the electric arc, the thermo-couple employed as pyrometer consisting of a rod of iridium, and a rod of an alloy of the same metal with 10 per cent of platinum. The temperature thus reached is stated to be the highest yet measured, viz., 2,000° C., and thus it is now possible to measure temperatures ranging from − 200° C. to + 2,000° C., the former temperature having been attained by Professor Dewar in his lecture to the Royal Institution some short time back.

Even before the invention of this instrument, Professor Roberts-Austen stated that very considerable progress had been made in pyrometry, so that Mr. Callender, with his improved Siemens apparatus, in which the change in the resistance of a platinum coil, as it grows hotter, is used as a measure of the temperature to which it is exposed, has succeeded in measuring temperatures of 1,500° C., with an error of not more than one-tenth of a degree.

In measuring lower temperatures than the fusing point of iridium, the thermo-couple used consisted of a couple of wires, one of platinum and the other of an alloy of this metal with 10 per cent of rhodium, simply twisted together. This couple was inserted in the mass of a clay dish, on which gold and palladium, etc., were melted by the aid of an oxy-hydrogen flame. The ends of the wires were coupled with a suitable reflecting galvanometer, which by means of a powerful lantern threw a bright spot of light on a long scale fixed to the wall of the lecture-room. By means of this apparatus Professor Roberts-Austen was able to exhibit the recalescence of iron and show that at this point the metal suddenly becomes magnetic. For this purpose a block of iron heated to redness was placed on a stand fitted with a thermo-couple and an ordinary magnetic needle, which carried a mirror reflecting a second spot of light on the screen. At a high temperature iron is non-magnetic, but as it cooled down the spot of light from the pyrometer travelled down its scale, till at the point of recalescence it became stationary, and at the same moment the second spot of light connected with the magnetic needle suddenly swung over, showing that the metal had then become magnetic. Of more immediate interest, from a practical point of view, was a second experiment exhibited. In this a bar of iron, heated to bright redness, was fixed at one end and loaded at the other. Instead of bending over under the influence of the weight, which of course was not large, it remained rigid until it had cooled down to its point of recalescence, when it suddenly began to deflect.

Professor Roberts-Austen maintains that these peculiarities point to a re-arrangement of the molecules of the metal, and that they occur even with chemically pure iron, being intrinsic in the metal and not merely the effect of foreign constituents, though of course these are of considerable importance in modifying the results observed. That such changes occur in practice there can be little doubt, though the effects seem often to be peculiarly local. Steel plates showing very considerable ductility on test have snapped simply from internal stresses without showing the slightest signs of elongation or